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**(54) TOPOLOGY DETERMINATION METHOD, MESSAGE RESPONSE METHOD, CONTROLLER AND SWITCH**

(57) Embodiments of this application disclose a topology determining method, used by an OFC to determine a complete topology structure of a hybrid SDN-IP network. The method in the embodiments of this application includes: receiving, by an OFC, a first message forwarded by a first OFS, where a first port of the first OFS is connected to a second port of a first TS, and the first message includes identification information of the first TS and information about the second port; determining information about a link from the first TS to the first OFS based on the first message; sending a second message to the first OFS, and instructing the first OFS to forward the second message on the first port, so that the first TS obtains information about a link from the first OFS to the first TS; sending a third message, where the third message is used to request management information base MIB information of the first TS; receiving a response message of the third message, where the response message of the third message carries the MIB information of the first TS; and obtaining the information about the link from the first OFS to the first TS and information about a link from a second TS to the first TS based on the MIB information of the first TS.

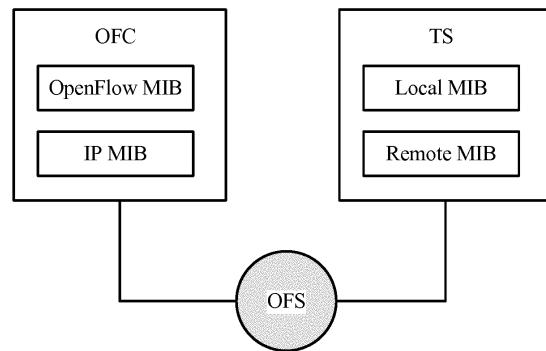


FIG. 2

## Description

**[0001]** This application claims priority to Chinese Patent Application No. 201610503105.8, filed with the Chinese Patent Office on June 30, 2016 and entitled "TOPOLOGY DETERMINING METHOD, MESSAGE RESPONSE METHOD, CONTROLLER, AND SWITCH", which is incorporated herein by reference in its entirety.

## TECHNICAL FIELD

**[0002]** This application relates to the communications field, and in particular, to a topology determining method, a message response method, a controller, and a switch.

## BACKGROUND

**[0003]** A software-defined network (English: software-defined network, SDN for short) is a new network. In OpenFlow (English: OpenFlow), a core technology of the SDN, a control plane and a data plane of a network device are separated, implementing flexible network traffic control. As a result, a network becomes more intelligent as a channel.

**[0004]** At a current stage, a traditional Internet Protocol (English: internet protocol, IP for short) network is in gradual transition to an SDN network. In the transition process, there may be both a traditional (English: traditional) switch (English: switch) and an OpenFlow switch (English: OpenFlow switch, OFS for short) in a network of an operator, and a hybrid SDN-IP network in which the traditional switch coexists with the OFS is formed. For ease of description, the traditional switch is collectively referred to as TS for short below. In this application, a TS is a device that has a forwarding function and that runs the IP protocol. In actual application, the TS may be a switch that performs layer 2 or layer 3 forwarding, or a router that performs layer 3 forwarding.

**[0005]** In addition to the OFS and the TS, the hybrid SDN-IP network further includes an OpenFlow controller (English: OpenFlow controller, OFC for short) configured to control and manage the OFS in the network. While an existing TS design is not changed, the OFS may discover, by using the Link Layer Discovery Protocol (English: link layer discovery protocol, LLDP for short), the TS connected to the OFS, and report the TS to the OFC, so that the OFC learns of a link from the TS to the OFS. However, the OFC cannot learn of a link from the OFS to the TS, and cannot learn of a link between TSs, either. In other words, in the prior art, the OFC cannot learn of a complete topology structure of the hybrid SDN-IP network, and an optimal path cannot be determined during end-to-end routing, resulting in relatively low forwarding performance of the hybrid SDN-IP network.

## SUMMARY

**[0006]** This application provides a topology determin-

ing method, used by an OFC to obtain a topology structure of a hybrid SDN-IP network.

**[0007]** A first aspect of this application provides a topology determining method, including: receiving, by an OFC from a first OFS, a first message from a first TS, where a first port of the first OFS is connected to a second port of the first TS, and the first message includes identification information of the first TS and information about the second port; obtaining, by the OFC, information about a link from the first TS to the first OFS based on the first message; sending, by the OFC, a second message to the first OFS, where the second message includes a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS can receive the second message on the second port, to obtain information about a link from the first OFS to the first TS; sending, by the OFC, a third message to the first OFS, where the third message is used to request management information base (English: management information base, MIB for short) information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port, so that the third message is received by the first TS; receiving, by the OFC from the first OFS, a response message, sent by the first TS, of the third message, where the response message of the third message carries the MIB information of the first TS; and obtaining, by the OFC, the information about the link from the first OFS to the first TS and information about a link from a second TS to the first TS based on the MIB information of the first TS, where the second TS is connected to the first TS. In this application, the OFC in a hybrid SDN-IP network requests MIB information of a TS from the TS, and obtains, from the MIB information of the TS, information about a link from an OFS to the TS and information about a link between TSs. In this way, the OFC can determine a complete topology structure of the hybrid SDN-IP network, and an optimal routing path can be determined in a subsequent routing calculation process, thereby improving forwarding performance of the hybrid SDN-IP network.

**[0008]** Optionally, the MIB message of the first TS includes identification information of the second TS. After obtaining the MIB information of the first TS, the OFC may further send a fourth message to the first OFS based on the identification information of the second TS, where the fourth message is used to request MIB information of the second TS. The fourth message carries a third instruction used to instruct the first OFS to forward the third message on the first port, so that the third message can be received by the first TS. The fourth message further includes a source routing domain field, where the source routing domain field includes the identification information of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS. The OFC receives a response message of the fourth message, where the response message of the fourth

message is sent by the second TS, and is forwarded sequentially by the first TS and the first OFS to the OFC. The response message of the fourth message carries the MIB information of the second TS. The OFC obtains, through calculation, information about a link from a third TS to the second TS based on the MIB information of the second TS, where the third TS is connected to the second TS.

**[0009]** Optionally, the OFC includes an IP MIB and an OpenFlow MIB. The OFC saves the MIB information of the first TS and the MIB information of the second TS in the IP MIB, and saves, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

**[0010]** Optionally, the third message includes a Simple Network Management Protocol (English: simple network management protocol, SNMP for short) request (English: get-request) message, and the first SNMP get-request message is used to request the MIB information of the first TS. The response message of the third message includes a first SNMP response (English: get-response) message, and the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

**[0011]** Optionally, the third message may be in a form of a packet out message, and in addition to the first SNMP get-request message encapsulated in the third message, the third message includes an ofp\_action\_type field. Content filling the ofp\_action\_type field in the third message is used to indicate that an SNMP get-request message is encapsulated in the third message. Correspondingly, the response message of the third message may be in a form of a packet in message, and in addition to the first SNMP get-response message encapsulated in the response message, the response message of the third message includes a reason field. The reason field in the packet in message is used to indicate a reporting reason of the packet in message, and content filling the reason field in the response message of the third message is used to indicate that the response message of the third message carries MIB information of a TS, and specifically carries the MIB information of the first TS.

**[0012]** Optionally, the fourth message may be in a form of a packet out message, and in addition to the second SNMP get-request message encapsulated in the fourth message, the fourth message includes an ofp\_action\_type field, and content filling the ofp\_action\_type field in the fourth message is used to indicate that an SNMP get-request message is encapsulated in the fourth message. Correspondingly, the response message of the fourth message may be in a form of a packet in message, and in addition to the second SNMP get-response message encapsulated in the re-

sponse message, the response message of the fourth message includes a reason field. The reason field in the response message of the fourth message is used to indicate that the response message of the fourth message carries MIB information of a TS, and specifically carries the MIB information of the second TS.

**[0013]** Optionally, a first LLDP packet is encapsulated in the first message, and the first LLDP packet carries the identification information of the first TS and the information about the second port.

**[0014]** A second aspect of this application provides a message response method, applicable to a first TS in a hybrid SDN-IP network, including: receiving, by the first TS, a third message on a second port, where the third message is sent by an OFC, and is used by the OFC to request MIB information of the first TS; and sending, by the first TS, a response message of the third message on the second port, where the response message of the third message carries the MIB information of the first TS.

20 In this way, the first TS can feed back the MIB information of the first TS to the OFC, so that the OFC can complete a topology structure of the hybrid SDN-IP network.

**[0015]** Optionally, the second port of the first TS is connected to a first port of a first OFS. The third message is sent by the OFC to the first OFS, and the OFC instructs the first OFS to forward the third message on the first port, so that the third message is received by the first TS.

**[0016]** Optionally, the second port of the first TS is connected to another TS other than the first TS in the hybrid SDN-IP network, for example, is connected to a target TS. The third message is forwarded by the OFC to the target TS, and the OFC instructs the target TS to forward the third message to the first TS.

**[0017]** Optionally, the first TS may further receive a fourth message on the second port, where the fourth message is used to request MIB information of a second TS, the fourth message includes a source routing domain field, the source routing domain field includes identification information of the second TS, and the second TS is connected to the first TS. The first TS forwards the fourth message to the second TS in a source routing manner according to an instruction of the source routing domain field. The first TS is further configured to: receive a response message, returned by the second TS, of the

40 fourth message, and send the response message of the fourth message on the second port, so that the response message of the fourth message can be sent to the OFC according to a link reverse to that of the fourth message. The response message of the fourth message carries the MIB information of the second TS.

**[0018]** Optionally, the third message includes a first SNMP get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS. The response message of the third message includes a first SNMP get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the

second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

**[0019]** A third aspect of the present invention provides an OFC, applicable to a hybrid SDN-IP network, including: a message receiving module, configured to receive a first message forwarded by a first OpenFlow switch OFS, where a first port of the first OFS is connected to a second port of a first TS, the first message is sent by the first TS to the first OFS, and then is forwarded by the first OFS to the OFC, and the first message includes identification information of the first TS and information about the second port; a message processing module, configured to determine information about a link from the first TS to the first OFS based on the first message; and a message sending module, configured to send a second message to the first OFS, where the second message includes a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS obtains information about a link from the first OFS to the first TS. The message sending module is further configured to send a third message to the first OFS, where the third message is used to request MIB information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port. The message receiving module is further configured to receive a response message, forwarded by the first OFS, of the third message, where the response message of the third message is sent by the first TS, and the response message of the third message carries the MIB information of the first TS. The message processing module is further configured to obtain the information about the link from the first OFS to the first TS and information about a link from a second TS to the first TS based on the MIB information of the first TS. The OFC requests MIB information of a TS from the TS, obtains, from the MIB information of the TS, information about a link from an OFS to the TS and information about a link between TSs, and can determine a complete topology structure of the hybrid SDN-IP network. An optimal routing path can be determined in a subsequent routing calculation process, and forwarding performance of the hybrid SDN-IP network is improved.

**[0020]** Optionally, the MIB message of the first TS includes identification information of the second TS. The message sending module is further configured to send a fourth message to the first OFS, where the fourth message is used to request MIB information of the second TS, the fourth message carries a third instruction used to instruct the first OFS to forward the third message on the first port, the fourth message further includes a source routing domain field, and the source routing domain field includes the identification information of the second TS, and is used to instruct the first TS to forward the fourth

message to the second TS. The message receiving module is further configured to receive a response message, forwarded by the first OFS, of the fourth message, where the response message of the fourth message is sent by the second TS, and the response message of the fourth message carries the MIB information of the second TS. The message processing module is further configured to obtain information about a link from a third TS to the second TS based on the MIB information of the second TS, where the third TS is connected to the second TS.

**[0021]** Optionally, the OFC includes an IP MIB and an OpenFlow OpenFlow MIB, and the message processing module is further configured to: save the MIB information of the first TS and the MIB information of the second TS in the IP MIB of the OFC, and save, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

**[0022]** Optionally, the third message includes a first SNMP get-request message, and the first SNMP get-request message is used to request the management information base MIB information of the first TS. The response message of the third message includes a first SNMP get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

**[0023]** Optionally, the response message of the third message is a packet in message in which the first SNMP get-response message is encapsulated, the response message of the third message further includes a reason field, and the reason field in the response message of the third message is used to indicate that the response message of the third message carries the MIB information of the first TS. The response message of the fourth message is a packet in message in which the second SNMP get-response message is encapsulated, the response message of the fourth message further includes a reason field, and the reason field in the response message of the fourth message is used to indicate that the response message of the fourth message carries the MIB information of the second TS.

**[0024]** Optionally, a first LLDP packet is encapsulated in the first message, and the first LLDP packet carries the identification information of the first TS and the information about the second port.

**[0025]** A fourth aspect of this application provides a TS, serving as a first TS in a hybrid SDN-IP network. The TS includes: a message receiving module, configured to receive a third message on a second port of the first TS, where the third message is used by an OFC to request MIB information of the first TS; and a message sending module, configured to send a response message of the third message on the second port, where the response

message of the third message carries the MIB information of the first TS. The first TS provided in this application can feed back the MIB information of the first TS to the OFC, so that the OFC can complete a topology structure of the hybrid SDN-IP network.

[0026] Optionally, the second port of the first TS is connected to a first port of a first OFS, and the OFC instructs the first OFS to forward the third message on the first port.

[0027] Optionally, the second port of the first TS is connected to a target TS other than the first TS in the hybrid SDN-IP network, and the OFC instructs the target TS to forward the third message to the first TS.

[0028] Optionally, the message receiving module is further configured to receive a fourth message on the second port, where the fourth message is used to request MIB information of a second TS, the fourth message includes a source routing domain field, the source routing domain field includes identification information of the second TS, and the second TS is connected to the first TS. The message sending module is further configured to forward the fourth message to the second TS according to an instruction of the source routing domain field. The message receiving module is further configured to receive a response message, returned by the second TS, of the fourth message, where the response message of the fourth message carries the MIB information of the second TS. The message sending module is further configured to send the response message of the fourth message on the second port.

[0029] Optionally, the third message includes a first SNMP get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS. The response message of the third message includes a first SNMP get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

[0030] A fifth aspect of this application provides an OFC, including a processor, a memory, a communications interface, and a bus. The processor invokes a program stored in the memory, to perform the method provided in the first aspect of this application.

[0031] A sixth aspect of this application provides a TS, including a processor, a memory, a communications interface, and a bus. The processor invokes a program stored in the memory, to perform the method provided in the second aspect of this application.

#### BRIEF DESCRIPTION OF DRAWINGS

[0032]

FIG. 1 is a schematic diagram of an architecture of a hybrid SDN-IP network;

FIG. 2 is a schematic diagram of another architecture of a hybrid SDN-IP network;

FIG. 3 (a) is a structural diagram of an embodiment of an OFC according to this application;

FIG. 3 (b) is a structural diagram of an embodiment of a TS according to this application;

FIG. 4 (a) is a schematic diagram of a format of an LLDP packet;

FIG. 4 (b) is a schematic diagram of a format of an SNMP message;

FIG. 5 (a) is a schematic diagram of a principle of discovering links between a first TS and a second TS according to this application;

FIG. 5 (b) is a schematic diagram of a principle of discovering a link from a first TS to a first OFS according to this application;

FIG. 5 (c) is a schematic diagram of a principle of discovering a link from a first OFS to a first TS according to this application;

FIG. 5 (d) is a schematic diagram of a principle of obtaining MIB information of a first TS by an OFC according to this application;

FIG. 5 (e) is a schematic diagram of a principle of obtaining MIB information of a second TS by an OFC according to this application;

FIG. 6 is a flowchart of an embodiment of a topology determining method according to this application;

FIG. 7 is a structural diagram of another embodiment of an OFC according to this application; and

FIG. 8 is a structural diagram of another embodiment of a TS according to this application.

#### DESCRIPTION OF EMBODIMENTS

[0033] This application provides a topology determining method, used by an OFC to determine a complete topology of a hybrid SDN-IP network. This application further provides a related OFC and TS, and descriptions are separately provided in the following.

[0034] A hybrid SDN-IP network is used in transition from a traditional IP network to a new SDN network. FIG. 1 is a schematic diagram of an architecture of a hybrid SDN-IP network. The hybrid SDN-IP network includes an OFC and one or more OFSs. It can be seen from FIG. 1 that, in addition to the OFSs and the OFC used to manage the OFSs, the hybrid SDN-IP network may include TSs connected to the OFSs. The OFC is not directly connected to the TSs, and therefore the OFC does not directly control and manage the TSs.

[0035] LLDP is a standard link layer discovery manner. In this manner, information about a local end device such as a main capability, a management address, a device identifier, and an interface identifier may be organized into different type-length-values (English: type/length/value, TLV for short), is encapsulated in a Link Layer Discovery Protocol data unit (English: link lay-

er discovery protocol data unit, LLDPDU for short), and is released, in an LLDP packet form, to a neighbor directly connected to the local end device. After receiving the information, the neighbor saves the information in an MIB information form, so that a system can query and determine a link communication status.

**[0036]** An MIB is one piece of content of a Transmission Control Protocol/Internet Protocol (English: transmission control protocol/internet protocol, TCP/IP for short) standard framework. The MIB defines a data element that needs to be stored in a managed device, an operation allowed to be performed on each data element, and meaning of the operation. In other words, a data variable such as control and status information of a managed device that can be accessed by a management system is stored in the MIB. In this application, information such as a connection relationship between devices in the hybrid SDN-IP network is stored in an MIB of each network device.

**[0037]** FIG. 2 is a schematic diagram of another architecture of a hybrid SDN-IP network. An MIB of a TS includes at least an LLDP local system MIB (English: LLDP Local System MIB, local MIB for short) and an LLDP remote system MIB (English: LLDP Remote System MIB, remote MIB for short). The local MIB is used to store information about a local device of the TS, including information about the local device such as a device identifier (English: ID), an interface ID, a system name, a system description, an interface description, a device capability, and a network management address. The remote MIB is used to store information about a neighboring device, including information about the neighboring device such as a device ID, an interface ID, a system name, a system description, an interface description, a device capability, and a network management address.

**[0038]** Still as shown in FIG. 2, because the hybrid SDN-IP network includes both an OFS using the OpenFlow protocol and a TS using the TCP/IP protocol, an MIB of an OFC in this application includes at least an OpenFlow MIB and an IP MIB. The OpenFlow MIB is mainly used to store device information of the OFS, information about a link between OFSs, and information about a link from the TS to the OFS, and the IP MIB is mainly used to store MIB information of the TS that is requested from the TS.

**[0039]** Optionally, the hybrid SDN-IP network may perform unified management on the OFC and the TS by using a network management system. For example, a network management server (English: network management server, NMS for short) may be deployed on the OFC to manage the OpenFlow MIB and the IP MIB on the OFC, for example, parse a received message, save, in the OpenFlow MIB or the IP MIB, required content in the message, and calculate a network topology based on information stored in the OpenFlow MIB and the IP MIB. Correspondingly, a network management agent (English: network management agent, NMA for short) may be deployed on the TS to manage local MIB infor-

mation and remote MIB information on the TS.

**[0040]** The OFC shown in FIG. 1 and FIG. 2 may be implemented by an OFC 300 shown in FIG. 3 (a), and the OFC 300 mainly includes a processor 301, a memory 302, a communications interface 303, and a bus 304. The processor 301, the memory 302, and the communications interface 303 may implement mutual communication connection by using the bus 304 or may implement communication by other means such as wireless transmission.

**[0041]** The memory 302 may be a volatile storage medium (English: volatile memory) such as a random-access memory (English: random-access memory, RAM for short), or may be a non-volatile storage medium.

15 When the technical solutions provided in this application are implemented by using software, program code used to implement the method provided in this application may be stored in the memory 302, and may be executed by the processor 301.

**[0042]** The processor 301 may be any one or a combination of the following hardware units with a processing function: a CPU, a graphics processing unit (English: graphics processing unit, GPU for short), digital signal processing (English: digital signal processing, DSP for short), an ASIC, an FPGA, a hardware chip, and the like. The processor 301 is mainly configured to: control the communications interface 303 to receive a first message forwarded by a first OFS, where a first port of the first OFS is connected to a second port of a first traditional

30 switch TS, the first message is sent by the first TS to the first OFS, and the first message includes identification information of the first TS and information about the second port; determine information about a link from the first TS to the first OFS based on the first message; send a second message to the first OFS, where the second message includes a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS obtains information about a link from the first OFS to the first TS;

35 send a third message to the first OFS, where the third message is used to request management information base MIB information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port; receive a response message, forwarded by the first OFS, of the third message, where the response message of the third message is sent by the first TS, and the response message of the third message carries the MIB information of the first TS; and obtain the information about the link from the first OFS to the first TS and information about a link from a second TS to the first TS based on the MIB information of the first TS.

**[0043]** Optionally, the MIB message of the first TS includes identification information of the second TS. The processor 301 is further configured to: send a fourth message to the first OFS, where the fourth message is used to request MIB information of the second TS, the fourth message carries a third instruction used to instruct the

first OFS to forward the third message on the first port, the fourth message further includes a source routing domain field, and the source routing domain field includes the identification information of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS; receive a response message, forwarded by the first OFS, of the fourth message, where the response message of the fourth message is sent by the second TS, and the response message of the fourth message carries the MIB information of the second TS; and obtain information about a link from a third TS to the second TS based on the MIB information of the second TS, where the third TS is connected to the second TS.

**[0044]** Optionally, the memory 302 includes an IP MIB and an OpenFlow MIB, and the processor 301 is further configured to: save the MIB information of the first TS and the MIB information of the second TS in the IP MIB of the OFC, and save, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

**[0045]** The TS shown in FIG. 1 and FIG. 2 may be implemented by a TS 310 shown in FIG. 3 (b), and the TS 310 mainly includes a processor 311, a memory 312, a communications interface 313, and a bus 314. The processor 311, the memory 312, and the communications interface 313 may implement mutual communication connection by using the bus 314 or may implement communication by other means such as wireless transmission.

**[0046]** The memory 312 may be a volatile storage medium such as a RAM, or may be a non-volatile storage medium. Local MIB information and remote MIB information of the TS are stored in the memory 312. When the technical solutions provided in this application are implemented by using software, program code used to implement the method provided in this application may be stored in the memory 302, and may be executed by the processor 311.

**[0047]** The processor 311 may be any one or a combination of the following hardware units with a processing function: a CPU, a GPU, a DSP, an ASIC, an FPGA, a hardware chip, and the like. The processor 311 is mainly configured to: control the communications interface 313 to receive a third message, and generate a response message of the third message for sending on the communications interface 313. The third message is used by an OFC to request MIB information of a first TS, and the response message of the third message carries the MIB information of the first TS.

**[0048]** Optionally, the processor 311 is further configured to: control the communications interface 313 to receive a fourth message, where the fourth message includes a source routing domain field, the source routing domain field includes identification information of a second TS, and the second TS is connected to the first TS; forward the fourth message to the second TS according to an instruction of the source routing domain field by using the communications interface 313; control the communications interface 313 to receive a response mes-

sage, returned by the second TS, of the fourth message, where the response message of the fourth message carries MIB information of the second TS; and send the response message of the fourth message on a second port by using the communications port 313.

**[0049]** The following gradually describes, with reference to the hybrid SDN-IP network architecture shown in FIG. 1 by using an example of determining a topology relationship among the OFC, the first OFS, the first TS, and the second TS, a basic principle of a topology determining method proposed in this application.

(I) Mutual discovery between the first TS and the second TS:

**[0050]** Refer to FIG. 5 (a). A switch periodically sends an LLDP packet to a neighboring device in a normal working mode, to notify the neighboring device of local device information. When a local configuration changes, the switch immediately sends an LLDP packet to the neighboring device, to notify the neighboring device of a change of the local device information. Link discovery between TSs in this application uses this traditional discovery manner.

**[0051]** In an example of the first TS, the first TS constructs a first LLDP packet, and periodically sends the constructed first LLDP packet from local active ports through multicast, as shown in step 501. The first LLDP packet carries device information of the first TS. After receiving the first LLDP packet, the second TS can obtain the device information of the first TS by parsing an LLDPDU in the first LLDP packet. The second TS updates the obtained device information of the first TS to a remote MIB of the second TS. In this way, the second TS discovers the first TS.

**[0052]** An LLDP packet is usually encapsulated in an Ethernet (English: ethernet) II manner and a Subnetwork Access Protocol (English: subnetwork access protocol, SNAP for short) manner. An encapsulated LLDP packet mainly includes the following parts: (1) a destination MAC address (English: destination MAC address, Dst\_MAC for short), (2) a source MAC address (English: source MAC address, Src\_MAC for short), (3) an Ethernet type (English: ethernet type, Eth\_Type for short), (4) data (English: data) that is an LLDPDU, and (5) a frame check sequence (English: frame check sequence, FCS for short). FIG. 4 (a) is a schematic diagram of a format of the LLDP packet encapsulated in the Ethernet II manner.

**[0053]** Data in the LLDPDU is organized in a TLV form, and includes at least: (1) a chassis ID used to send (English: Chassis ID) a bridge MAC address of a device, (2) a port number (English: Port ID) of an LLDPDU sending port, (3) a time to live (English: Time to Live) of information about this device on a neighboring device, and (4) an end identifier of the LLDPDU (End of LLDPDU).

**[0054]** Based on the description of the LLDP packet format, this application provides a specific instance of the first LLDP packet. Instances provided in this applica-

tion provide only an example of a value of each field in a packet or a message, and each field in the packet or message may also be another value in actual application:

5 Dst\_MAC: 01-80-C2-00-00-0E  
 Src\_MAC: MAC address of the first TS  
 Eth\_Type: 0x88CC  
 LLDPDU:  
 10 Chassis ID: subtype (English: subtype)=5, and carrying an IP address of the first TS  
 Port ID: subtype=2, port information (English: Port Component)  
 Time to Live: 3  
 End of LLDPDU

**[0055]** The first TS may also discover the second TS based on a same method, and details are not described herein again.

(II) Discovery of a link from the first TS to the first OFS:

**[0056]** Refer to FIG. 5 (b). In (I), the first TS sends the first LLDP packet through multicast, and the first LLDP packet may also be received by the neighboring first OFS.

After receiving the first LLDP packet, the first OFS encapsulates the first LLDP packet in its entirety in a first packet in (English: Packet In) message and reports the first packet in message to the OFC, as shown in step 502.  
**[0057]** After receiving the first packet in message sent by the first OFS, the OFC parses the first LLDP packet in the first packet in message, to obtain information about the link from the first TS to the first OFS.

**[0058]** A packet in message includes a "reason" field used to indicate a reporting reason of the packet in message. In this application, a "reason" field in the first packet in message is used to indicate that the first packet in message is used to report the information about the link from the first TS to the first OFS.

**[0059]** Complete link information includes identification information of a source end device, port information of the source end device, identification information of a destination end device, and port information of the destination end device. Identification information of a device may be an IP address, a MAC address, or a device ID of the device, or may be other information that can uniquely identify the device. Port information of a device may be a port number of a port through which the device accesses a link. For example, the information about the link from the first TS to the first OFS may include the IP address of the first TS, information about a second port, connected to the first OFS, of the first TS, an IP address of the first OFS, and port information of a first port, connected to the first TS, of the first OFS.

**[0060]** After obtaining the information about the link from the first TS to the first OFS, the OFC saves the information about the link from the first TS to the first OFS in a local OpenFlow MIB of the OFC.

(III) Discovery of a link from the first OFS to the first TS:

**[0061]** Refer to FIG. 5 (c). In (II), the OFC learns of the port information of the first port, connected to the first TS, of the first OFS. Therefore, the OFC constructs a first packet out (English: Packet Out) message and sends the first packet out message to the first OFS, as shown in step 503. A first instruction is encapsulated in the first packet out message, and the first instruction is used to instruct the first OFS to forward the first packet out message on the first port. A second LLDP packet is also encapsulated in the first packet out message. A specific instance of the second LLDP packet is as follows:

15 Dst\_MAC: 01-80-C2-00-00-0E  
 Src\_MAC: MAC address of the first port of the first OFS  
 Eth\_Type: 0x88CC  
 LLDPDU:  
 20 Chassis ID: subtype=5, and carrying the IP address of the first OFS  
 Port ID: subtype=2, Port Component  
 Time to Live: 3  
 End of LLDPDU

**[0062]** After receiving the first packet out message, the first OFS forwards the second LLDP packet on the first port according to an instruction of the first instruction encapsulated in the first packet out message, and the connected first TS receives the second LLDP packet, as shown in step 504.

**[0063]** The first TS can obtain device information of the first OFS by parsing the second LLDP packet, for example, the IP address of the first OFS and the port information of the first port of the first OFS. The first TS updates the obtained device information of the first OFS to a remote MIB of the first TS. In this way, the link from the first OFS to the first TS is discovered.

40 (IV) The OFC obtains MIB information of the first TS.

**[0064]** Refer to FIG. 5 (d). After delivering the first packet out message, the OFC constructs a second packet out message and sends the second packet out message to the first OFS, as shown in step 505. A second instruction is encapsulated in the second packet out message, and the second instruction is used to instruct the first OFS to forward the first packet out message on the first port. A first SNMP get-request message is also encapsulated in the second packet out message, and the first SNMP get-request message is used by the OFC to request to-be-obtained information from the first TS. The to-be-obtained information may be all MIB information of the first TS, or may be only partial MIB information of the first TS. The to-be-obtained information may be in local MIB information of the first TS, or may be in a remote MIB information of the first TS.

**[0065]** A packet out message includes an "ofp\_action\_type" field used to indicate a task type of the packet out message. In this application, an "ofp\_action\_type" field in the second packet out message is used to indicate that the second packet out message carries an SNMP get-request message.

**[0066]** In a payload (English: payload) of the second packet out message, a destination MAC address is a MAC address of the second port, connected to an OFS, of the first TS, a source MAC address is the MAC address of the first port of the first OFS, a destination IP address is the IP address of the first TS, and a source IP address is the IP address of the first OFS. In addition, the first SNMP get-request message is also encapsulated in the payload of the second packet out message.

**[0067]** For a specific format of an SNMP message, refer to FIG. 4 (b). The SNMP message usually includes two parts: an SNMP header and a protocol data unit (English: protocol data unit, PDU for short). The SNMP header further includes an SNMP version (English: Version) number and a community (English: Community) name, and the PDU carries a PDU type (English: Type). A type 0 is used to indicate a get-request message, and a type 2 is used to indicate a get-response.

**[0068]** In this application, a specific instance of the first SNMP get-request message is as follows:

Version: SNMP version number minus 1

Community: public

PDU: type=0, and carrying the MIB information of the first TS that is to be obtained by the OFC, including a local MIB and a remote MIB of the first TS

**[0069]** After receiving the second packet out message, the first OFS forwards the first SNMP get-request message in the second packet out message on the first port according to the second instruction, and the connected first TS receives the first SNMP get-request message, as shown in step 506.

**[0070]** After receiving the first SNMP get-request message, the first TS searches, based on a requirement of the first SNMP get-request message, the local MIB and the remote MIB of the first TS for an actual value of the information to be obtained by the OFC, encapsulates a search result in a first SNMP get-response message, and returns the first SNMP get-response message to the first OFS, as shown in step 507.

**[0071]** In this application, a specific instance of the first SNMP get-response message is as follows:

Version: SNMP version number minus 1

Community: public

PDU: type=2, and carrying the MIB information of the first TS, including the actual value, found by the first TS, of the information to be obtained by the OFC.

**[0072]** After receiving the first SNMP get-response message sent by the first TS, the first OFS encapsulates

the first SNMP get-response message in its entirety in a second packet in message and reports the second packet in message to the OFC, as shown in step 508. A "reason" field in the second packet in message is used to indicate that the second packet in message is a response message that carries MIB information, to be specific, the second packet in message carries the MIB message of the first TS.

**[0073]** After receiving the second packet in message sent by the first OFS, the OFC can obtain the MIB information of the first TS by parsing the first SNMP get-response message in the second packet in message. The OFC saves, in an IP MIB of the OFC, required content in the obtained MIB information of the first TS, including the device information of the first TS stored in the local MIB information of the first TS, and device information of the second TS, the device information of the first OFS, and/or device information of another traditional switch that are/is stored in the remote MIB information of the first TS.

**[0074]** The OFC can obtain, through calculation based on the obtained MIB information of the first TS, information about a link from the first OFS to the first TS, information about a link from the second TS to the first TS, or information about a link from another traditional switch to the first TS.

**[0075]** It should be pointed out that, in the prior art, SNMP protocol communication between a TS and an OFC is implemented by using a network management system. Specifically, an NMA running on the TS directly exchanges an SNMP message with the OFC by using a special control port. In this application, an SNMP protocol message (including an SNMP get-request message, an SNMP get-response message, and the like) between the TS and the OFC is encapsulated in an OpenFlow protocol message for transmission, and therefore does not need to pass through the network management system, nor needs to be forwarded on the special control port. The TS communicates with the OFC according to a normal OpenFlow protocol rule.

(V) The OFC obtains MIB information of the second TS.

**[0076]** Refer to FIG. 5 (e). After obtaining the MIB information of the first TS, the OFC constructs a third packet out message and sends the third packet out message to the first OFS, as shown in step 509. A third instruction is encapsulated in the third packet out message, and the third instruction is used to instruct the first OFS to forward the first packet out message on the first port. The third packet out message further carries a second SNMP get-request message, and the second SNMP get-request message is used by the OFC to request to-be-obtained information from the second TS. The to-be-obtained information may be all MIB information of the second TS, or may be only partial MIB information of the second TS.

**[0077]** An "ofp\_action\_type" field in the third packet out message is used to indicate that the third packet out mes-

age carries an SNMP get-request message. In a payload of the third packet out message, a destination MAC address is the MAC address of the second port, connected to an OFS, of the first TS, a source MAC address is the MAC address of the first port of the first OFS, a destination IP address is the IP address of the first TS, and a source IP address is the IP address of the first OFS. The second SNMP get-request message is also encapsulated in the payload of the second packet out message. In addition, the payload of the second packet out message further includes a source routing domain field, and the field is filled in with an IP address of the second TS.

**[0078]** In this application, a specific instance of the second SNMP get-request message is as follows:

Version: SNMP version number minus 1  
 Community: public  
 PDU: type=0, and carrying information to be obtained by the OFC, including the local MIB and the remote MIB of the first TS

**[0079]** After receiving the third packet out message, the first OFS forwards the second SNMP get-request message in the third packet out message on the first port according to the third instruction, and the connected first TS receives the second SNMP get-request message, as shown in step 510.

**[0080]** After receiving the second SNMP get-request message, the first TS forwards the second SNMP get-request message to the second TS in a traditional strict source routing manner based on the source routing domain field, as shown in step 511.

**[0081]** After receiving the second SNMP get-request message, the second TS searches, based on a requirement of the second SNMP get-request message, a local MIB and a remote MIB of the second TS for an actual value of the information to be obtained by the OFC, and a search result is partial or all MIB information of the second TS. The second TS encapsulates the search result in a second SNMP get-response message and returns the second SNMP get-response message to the first TS, as shown in step 512.

**[0082]** In this application, a specific instance of the second SNMP get-response message is as follows:

Version: SNMP version number minus 1  
 Community: public  
 PDU: type=2, and carrying the MIB information of the second TS, including the actual value, found by the second TS, of the information to be obtained by the OFC.

**[0083]** After receiving the second SNMP get-response message, the first TS forwards the second SNMP get-response message to the first OFS in the traditional strict source routing manner, as shown in step 513. The first OFS encapsulates the second SNMP get-response message in a third packet in message and reports the third

packet in message to the OFC, as shown in step 514. A "reason" field in the third packet in message is used to indicate that the third packet in message is a response message that carries MIB information, to be specific, the third packet in message carries the MIB information of the second TS.

**[0084]** After receiving the third packet in message, the OFC can obtain the MIB information of the second TS by parsing the second SNMP get-response message in the third packet in message. The OFC saves, in the IP MIB of the OFC, required content in the MIB information of the second TS, including the device information of the second TS stored in local MIB information of the second TS, and the device information of the first TS, device information of a third TS, and/or device information of another traditional switch that are/is stored in remote MIB information of the second TS.

**[0085]** The OFC can obtain, through calculation based on the obtained MIB information of the second TS, information about a link from the first TS to the second TS, information about a link from the third TS to the second TS, or information about a link from another traditional switch to the second TS.

**25** (VI) The OFC obtains MIB information of another TS.

**[0086]** The OFC obtains the MIB information of the another TS based on a similar method of obtaining the MIB information of the second TS in (V), and details are not described herein again. The OFC saves, in the IP MIB of the OFC, required content in the MIB information of the another TS.

**[0087]** The OFC can obtain information about a link between other TSs in the hybrid SDN-IP network based on the MIB information of the another TS.

(VII) Link discovery related to OFSs.

**[0088]** The OFC may obtain information about a link between OFSs in an existing OpenFlow discovery manner, and details are not described herein. The information about the link between the OFSs is stored in the OpenFlow MIB of the OFC.

**[0089]** By using (I) to (VI), the OFC can obtain information about a link between an OFS and a TS and information about a link between TSs. In addition, based on the information about the link between the OFSs obtained by the OFC in (VII), the OFC can learn of a topology structure of the entire hybrid SDN-IP network.

**[0090]** According to the principle proposed in (I) to (VI), this application provides a topology determining method. When running, the OFC shown in FIG. 1 and FIG. 2 and a computing device shown in FIG. 3 perform the method. Referring to FIG. 6, a basic procedure of the method includes the following steps.

**[0091]** 601. A first OFS receives a first LLDP packet sent by a first TS.

**[0092]** The hybrid SDN-IP network architecture shown

in FIG. 1 and FIG. 2 is still used in this embodiment. As described in (II), the first TS sends the first LLDP packet through multicast, and the first LLDP packet is received by the neighboring first OFS. The first LLDP packet carries device information of the first TS, for example, may include identification information of the first TS and port information of a second port, connected to the first OFS, of the first TS.

**[0093]** 602. The first OFS sends a first message to the OFC.

**[0094]** After receiving the first LLDP packet, the first OFS encapsulates the first LLDP packet in its entirety in the first message and sends the first message to the OFC, and the OFC receives the first message.

**[0095]** Optionally, the first message may be the first packet in message in (II).

**[0096]** 603. The OFC determines information about a link from the first TS to the first OFS based on the first message.

**[0097]** As a manager of OFSs in a network, the OFC can learn of information in all aspects of the first OFS, such as device information, address information, and port information. Therefore, after receiving the first message, the OFC can determine the information about the link from the first TS to the first OFS.

**[0098]** Optionally, the OFC may save the obtained information about the link from the first TS to the first OFS in an OpenFlow MIB of the OFC.

**[0099]** 604. The OFC sends a second message to the first OFS.

**[0100]** The OFC sends the second message to the first OFS, and optionally, the second message may be the first packet out message in (III).

**[0101]** Optionally, a second LLDP packet is encapsulated in the second message, and the second LLDP packet carries the device information of the first OFS, for example, may include identification information of the first OFS and information about a first port of the first OFS.

**[0102]** A first instruction is encapsulated in the second message, and is used to instruct the first OFS to forward the second message on the first port. When the device information of the first OFS is carried in the second LLDP packet, the first instruction is specifically used to instruct the first OFS to forward the second LLDP packet on the first port.

**[0103]** 605. The OFS forwards the second message to the first TS.

**[0104]** After receiving the second message, the OFS forwards the second message on the first port according to an instruction of the first instruction, so that the second message is received by the first TS connected to the first port of the OFS.

**[0105]** 606. The first TS obtains information about a link from the first OFS to the first TS.

**[0106]** The first TS saves, in a remote MIB of the first TS, the device information of the first OFS in the second message, so that the information about the link from the first OFS to the first TS is determined.

**[0107]** 607. The OFC sends a third message to the first OFS.

**[0108]** The OFC sends the third message to the first OFS, and the third message is used to request MIB information of the first TS, specifically, may request all MIB information of the first TS, or may request partial MIB information of the first TS. Optionally, the third message may be the second packet out message in (IV).

**[0109]** Optionally, a first SNMP get-request message may be encapsulated in the third message, and a function of requesting the MIB information of the first TS may be implemented by using the first SNMP get-request message.

**[0110]** A second instruction is encapsulated in the third message, and is used to instruct the first OFS to forward the third message on the first port. When the first SNMP get-request message is encapsulated in the third message, the second instruction is specifically used to instruct the first OFS to forward the first SNMP get-request message on the first port.

**[0111]** Only a network topology shown in FIG. 1 is used as an example for description in this embodiment. However, optionally, in actual application, the second port of the first TS may not be connected to the first OFS, but is connected to a target TS other than the first TS in the hybrid SDN-IP network, such as a seventh TS and an eighth TS. In this case, the OFC may also instruct the target TS to send the third message to the first TS, and this is not limited herein.

**[0112]** 608. The first OFS forwards the third message to the first TS.

**[0113]** The first OFS forwards the third message on the first port according to the second instruction, so that the third message is received by the first TS.

**[0114]** 609. The first TS returns a response message of the third message to the first OFS.

**[0115]** After receiving the third message, the first TS generates the response message of the third message and returns the response message of the third message to the first OFS. The response message of the third message carries the MIB information of the first TS that may be specifically from a local MIB of the first TS and/or from a remote MIB of the first TS. The response message of the third message may carry all MIB information of the first TS, or may carry partial MIB information of the first TS based on a request of the third message.

**[0116]** Optionally, the response message of the third message may be a first SNMP get-response message.

**[0117]** 610. The first OFS sends the response message of the third message to the OFC.

**[0118]** The first OFS forwards the response message of the third message to the OFC, and the OFC receives the response message of the third message. Optionally, the first OFS may encapsulate the response message of the third message in its entirety in a second packet in message and forward the second packet in message to the OFC.

**[0119]** 611. The OFC obtains MIB information of the

first TS.

[0120] The OFC can obtain the MIB information of the first TS based on the response message of the third message, including the device information of the first TS stored in local MIB information of the first TS, and device information of a second TS, the device information of the first OFS, and/or device information of another traditional switch that are/is stored in remote MIB information of the first TS.

[0121] The OFC can obtain, through calculation based on the obtained MIB information of the first TS, the information about the link from the first OFS to the first TS, information about a link from the second TS to the first TS, or information about a link from another traditional switch to the first TS.

[0122] Optionally, the OFC may save the obtained MIB information of the first TS in an IP MIB of the OFC.

[0123] 612. The OFC sends a fourth message to the first OFS.

[0124] The OFC sends the fourth message to the first OFS, and the third message is used to request MIB information of the second TS, specifically, may request all MIB information of the second TS, or may request partial MIB information of the second TS. Optionally, the fourth message may be the third packet out message in (V).

[0125] Optionally, a second SNMP get-request message may be encapsulated in the fourth message, and a function of requesting the MIB information of the second TS may be implemented by using the second SNMP get-request message.

[0126] A third instruction is encapsulated in the fourth message, and is used to instruct the first OFS to forward the fourth message on the first port. When the second SNMP get-request message is encapsulated in the fourth message, the third instruction is specifically used to instruct the first OFS to forward the second SNMP get-request message on the first port.

[0127] The fourth message further includes a source routing domain field, and the field is filled in with an IP address of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS in a strict source routing manner.

[0128] 613. The first OFS forwards the fourth message to the first TS.

[0129] The first OFS forwards the fourth message on the first port according to the third instruction, so that the fourth message is received by the first TS.

[0130] 614. The first TS forwards the fourth message to a second TS.

[0131] After receiving the fourth message, the first TS forwards the fourth message in the source routing manner based on the source routing domain field in the fourth message, in other words, forwards the fourth message to the second TS.

[0132] 615. The second TS returns a response message of the fourth message to the first TS.

[0133] After receiving the fourth message, the second TS generates the response message of the fourth mes-

sage and returns the response message of the fourth message to the first TS. The response message of the fourth message carries the MIB information of the second TS that may be specifically from a local MIB of the second

5 TS or from a remote MIB of the second TS. The response message of the fourth message may carry all MIB information of the second TS, or may carry partial MIB information of the second TS based on a request of the fourth message.

10 [0134] The fourth message further includes a source routing domain field, and the field is filled in with an IP address of the first OFS, and is used to instruct the first TS to forward the fourth message to the first OFS in the strict source routing manner.

15 [0135] Optionally, the response message of the fourth message may be a second SNMP get-response message.

[0136] 616. The first TS forwards the response message of the fourth message to the first OFS.

20 [0137] The first TS still forwards the response message of the fourth message to the first OFS in the strict source routing manner.

[0138] 617. The first OFS sends the response message of the fourth message to the OFC.

25 [0139] The first OFS forwards the response message of the fourth message to the OFC, and the OFC receives the response message of the fourth message. Optionally, the first OFS may encapsulate the response message of the fourth message in its entirety in a third packet in message and forward the third packet in message to the OFC.

30 [0140] 618. The OFC obtains MIB information of the second TS.

[0141] The OFC can obtain the MIB information of the second TS based on the response message of the fourth message, including the device information of the second TS stored in local MIB information of the second TS, and the device information of the first TS, device information of a third TS, and/or device information of another traditional switch that are/is stored in remote MIB information of the second TS.

[0142] The OFC can obtain, through calculation based on the obtained MIB information of the second TS, information about a link from the first TS to the second TS, information about a link from the third TS to the second TS, or information about a link from another traditional switch to the second TS.

[0143] Optionally, the OFC may save the obtained MIB information of the second TS in the IP MIB of the OFC.

[0144] The OFS may further obtain MIB information of another TS according to a similar method of steps 613 to 618, and details are not described herein again. After the OFC obtains MIB information of all TSs in the hybrid SDN-IP network, the OFC can learn of all information about a link between TSs and all information about a link from an OFS to a TS in the hybrid SDN-IP network. In this way, the OFC obtains a complete topology structure of the hybrid SDN-IP network.

[0145] In this embodiment of this application, the OFC

in the hybrid SDN-IP network can obtain MIB information of a TS, and obtain information about a link from the OFS to the TS and information about a link between TSs. In this way, the OFC can determine the complete topology structure of the hybrid SDN-IP network, facilitating determining an optimal routing path during subsequent routing calculation.

**[0146]** The embodiments of this application further provide a related OFC and TS, to implement the method described in the foregoing embodiments.

**[0147]** Referring to FIG. 7, a basic structure of an OFC provided in an embodiment of this application includes:

a message receiving module 701, configured to receive a first message forwarded by a first OpenFlow switch OFS, where a first port of the first OFS is connected to a second port of a first TS, the first message is sent by the first TS to the first OFS, and then is forwarded by the first OFS to the OFC; and the first message includes identification information of the first TS and information about the second port; a message processing module 702, configured to determine information about a link from the first TS to the first OFS based on the first message; and a message sending module 703, configured to send a second message to the first OFS, where the second message includes a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS obtains information about a link from the first OFS to the first TS.

**[0148]** The message sending module 703 is further configured to send a third message to the first OFS, where the third message is used to request MIB information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port.

**[0149]** The message receiving module 701 is further configured to receive a response message, forwarded by the first OFS, of the third message, where the response message of the third message is sent by the first TS, and the response message of the third message carries the MIB information of the first TS.

**[0150]** The message processing module 702 is further configured to obtain the information about the link from the first OFS to the first TS and information about a link from a second TS to the first TS based on the MIB information of the first TS.

**[0151]** For a specific running method of the OFC in this embodiment, refer to related descriptions in the embodiments shown in FIG. 4 (a) to FIG. 6, and details are not described herein again.

**[0152]** Compared with the prior art, the OFC in this embodiment can obtain the MIB information of the first TS, and then obtain, through calculation, information about a link from another device in a network to the first TS based on the MIB information of the first TS, so that

the OFC can complete a topology structure of a hybrid SDN-IP network.

**[0153]** The OFC shown in FIG. 7 and the OFC shown in FIG. 3 (a) may be a same OFC. The message receiving module 701 and the message sending module 703 in FIG. 7 may be implemented by the communications interface 303 in FIG. 3 (a), and the message processing module 702 may be implemented by the processor 303 in FIG. 3 (a).

**[0154]** Optionally, the MIB message of the first TS includes identification information of the second TS. The message sending module 703 is further configured to send a fourth message to the first OFS, where the fourth message is used to request MIB information of the second TS, the fourth message carries a third instruction used to instruct the first OFS to forward the third message on the first port, the fourth message further includes a source routing domain field, and the source routing domain field includes the identification information of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS. The message receiving module 701 is further configured to receive a response message, forwarded by the first OFS, of the fourth message, where the response message of the fourth message is sent by the second TS, and the response message of the fourth message carries the MIB information of the second TS. The message processing module 702 is further configured to obtain information about a link from a third TS to the second TS based on the MIB information of the second TS, where the third TS is connected to the second TS.

**[0155]** Optionally, the OFC includes an IP MIB and an OpenFlow OpenFlow MIB, and the message processing module 702 is further configured to: save the MIB information of the first TS and the MIB information of the second TS in the IP MIB of the OFC, and save, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

**[0156]** Optionally, the third message includes a first SNMP get-request message, and the first SNMP get-request message is used to request the management information base MIB information of the first TS. The response message of the third message includes a first SNMP get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

**[0157]** Optionally, the response message of the third message is a packet in message in which the first SNMP get-response message is encapsulated, the response message of the third message further includes a reason field, and the reason field in the response message of the third message is used to indicate that the response

message of the third message carries the MIB information of the first TS. The response message of the fourth message is a packet in message in which the second SNMP get-response message is encapsulated, the response message of the fourth message further includes a reason field, and the reason field in the response message of the fourth message is used to indicate that the response message of the fourth message carries the MIB information of the second TS.

[0158] Optionally, a first LLDP packet is encapsulated in the first message, and the first LLDP packet carries the identification information of the first TS and the information about the second port.

[0159] Referring to FIG. 8, a basic structure of a TS is provided in an embodiment of this application. As a first TS in a hybrid SDN-IP network, a structure of the first TS includes:

a message receiving module 801, configured to receive a third message on a second port of the first TS, where the third message is used by an OFC to request management information base MIB information of the first TS; and  
 a message sending module 802, configured to send a response message of the third message on the second port, where the response message of the third message carries the MIB information of the first TS.

[0160] For a specific running method of the TS in this embodiment, refer to related descriptions in the embodiments shown in FIG. 4 (a) to FIG. 6, and details are not described herein again.

[0161] Compared with the prior art, the TS in this embodiment can feed back the MIB information of the TS to the OFC device, so that the OFC can complete a topology structure of the hybrid SDN-IP network.

[0162] The TS shown in FIG. 8 and the TS shown in FIG. 3 (b) may be a same TS. The message receiving module 801 and the message sending module 802 in FIG. 8 may be implemented by the communications interface 313 in FIG. 3 (b) and controlled by the processor 313 in FIG. 3 (b).

[0163] Optionally, the second port of the first TS is connected to a first port of a first OFS, and the OFC instructs the first OFS to forward the third message on the first port.

[0164] Optionally, the second port of the first TS is connected to a target TS other than the first TS in the hybrid SDN-IP network, and the OFC instructs the target TS to forward the third message to the first TS.

[0165] Optionally, the message receiving module 801 is further configured to receive a fourth message on the second port, where the fourth message is used to request MIB information of a second TS, the fourth message includes a source routing domain field, the source routing domain field includes identification information of the second TS, and the second TS is connected to the first TS. The message sending module 802 is further configured

to forward the fourth message to the second TS according to an instruction of the source routing domain field. The message receiving module 801 is further configured to receive a response message, returned by the second TS, of the fourth message, where the response message of the fourth message carries the MIB information of the second TS. The message sending module 802 is further configured to send the response message of the fourth message on the second port.

[0166] Optionally, the third message includes a first SNMP get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS. The response message of the third message includes a first SNMP get-response message, and

the first SNMP get-response message is used to carry the MIB information of the first TS. The fourth message includes a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS. The response message of the fourth message includes a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

[0167] It may be clearly understood by persons skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing system, apparatus, and unit, refer to a corresponding process in the foregoing method embodiments, and details are not described herein again.

[0168] The "first" and "second" in this application are merely intended to distinguish different technical features, and do not impose any limitation on the technical features. For example, a "first TS" in this application may also be a "second TS" in actual application.

[0169] In the several embodiments provided in this application, it should be understood that the disclosed system, apparatus, and method may be implemented in other manners. For example, the described apparatus embodiment is merely an example. For example, the unit division is merely logical function division and may be other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented by using some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

[0170] The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected based on actual requirements to achieve the objectives of the solutions of the embodiments.

[0171] In addition, functional units in the embodiments of this application may be integrated into one processing

unit, or each of the units may exist alone physically, or two or more units are integrated into one unit. The integrated unit may be implemented in a form of hardware, or may be implemented in a form of a software functional unit.

**[0172]** When the integrated unit is implemented in the form of a software functional unit and sold or used as an independent product, the integrated unit may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of this application essentially, or the part contributing to the prior art, or all or some of the technical solutions may be implemented in the form of a software product. The software product is stored in a storage medium and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) to perform all or some of the steps of the methods described in the embodiments of this application. The foregoing storage medium includes: any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (ROM, Read-Only Memory), a RAM, a magnetic disk, or an optical disc.

**[0173]** The foregoing embodiments are merely intended for describing the technical solutions of this application, but not for limiting this application. Although this application is described in detail with reference to the foregoing embodiments, persons of ordinary skill in the art should understand that they may still make modifications to the technical solutions described in the foregoing embodiments or make equivalent replacements to some technical features thereof, without departing from the spirit and scope of the technical solutions of the embodiments of this application.

## Claims

1. A topology determining method, wherein the method is applicable to an OpenFlow controller OFC in a hybrid software-defined network SDN-Internet Protocol IP network, and comprises:

receiving a first message forwarded by a first OpenFlow switch OFS, wherein a first port of the first OFS is connected to a second port of a first traditional switch TS, the first message is sent by the first TS to the first OFS, and the first message comprises identification information of the first TS and information about the second port;

determining information about a link from the first TS to the first OFS based on the first message;

sending a second message to the first OFS, wherein the second message comprises a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS obtains

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information about a link from the first OFS to the first TS;

sending a third message to the first OFS, wherein the third message is used to request management information base MIB information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port;

receiving a response message, forwarded by the first OFS, of the third message, wherein the response message of the third message is sent by the first TS, and the response message of the third message carries the MIB information of the first TS; and

obtaining, based on the MIB information of the first TS, the information about the link from the first OFS to the first TS and information about a link from a second TS connected to the first TS to the first TS.

2. The topology determining method according to claim 1, wherein the MIB message of the first TS comprises identification information of the second TS, and the method further comprises:

sending a fourth message to the first OFS, wherein the fourth message is used to request MIB information of the second TS, the fourth message carries a third instruction used to instruct the first OFS to forward the third message on the first port, the fourth message further comprises a source routing domain field, and the source routing domain field comprises the identification information of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS;

receiving a response message, forwarded by the first OFS, of the fourth message, wherein the response message of the fourth message is sent by the second TS, and the response message of the fourth message carries the MIB information of the second TS; and

obtaining information about a link from a third TS to the second TS based on the MIB information of the second TS, wherein the third TS is connected to the second TS.

3. The topology determining method according to claim 2, wherein the OFC comprises an IP MIB and an OpenFlow OpenFlow MIB; and the method further comprises: saving the MIB information of the first TS and the MIB information of the second TS in the IP MIB of the OFC, and saving, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

4. The topology determining method according to claim

2 or 3, wherein the third message comprises a first Simple Network Management Protocol SNMP request get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS; 5 the response message of the third message comprises a first SNMP response get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS; the fourth message comprises a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS; and the response message of the fourth message comprises a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

5. The topology determining method according to claim 4, wherein the response message of the third message is a packet in message in which the first SNMP get-response message is encapsulated, the response message of the third message further comprises a reason field, and the reason field in the response message of the third message is used to indicate that the response message of the third message carries the MIB information of the first TS; and the response message of the fourth message is a packet in message in which the second SNMP get-response message is encapsulated, the response message of the fourth message further comprises a reason field, and the reason field in the response message of the fourth message is used to indicate that the response message of the fourth message carries the MIB information of the second TS. 20

6. The topology determining method according to any one of claims 1 to 5, wherein a first Link Layer Discovery Protocol LLDP packet is encapsulated in the first message, and the first LLDP packet carries the identification information of the first TS and the information about the second port. 40

7. A message response method, applicable to a hybrid software-defined network SDN-Internet Protocol IP network, wherein the hybrid SDN-IP network comprises an OpenFlow controller OFC, a first OpenFlow switch OFS, and at least two traditional switches TSs, and the method comprises: 45

receiving, by a first TS, a third message on a second port of the first TS, wherein the third message is used by the OFC to request management information base MIB information of the first TS; and 50 sending, by the first TS, a response message of the third message on the second port, wherein the response message of the third message car-

ries the MIB information of the first TS.

8. The message response method according to claim 7, wherein the second port of the first TS is connected to a first port of the first OFS, and the OFC instructs the first OFS to forward the third message on the first port. 5

9. The message response method according to claim 7, wherein the second port of the first TS is connected to a target TS other than the first TS in the hybrid SDN-IP network, and the OFC instructs the target TS to forward the third message to the first TS. 10

10. The message response method according to any one of claims 7 to 9, wherein the method further comprises: 15

receiving, by the first TS, a fourth message on the second port, wherein the fourth message is used to request MIB information of a second TS, the fourth message comprises a source routing domain field, the source routing domain field comprises identification information of the second TS, and the second TS is connected to the first TS; 25 forwarding, by the first TS, the fourth message to the second TS according to an instruction of the source routing domain field; and receiving, by the first TS, a response message, returned by the second TS, of the fourth message, and sending the response message of the fourth message on the second port, wherein the response message of the fourth message carries the MIB information of the second TS. 30

11. The message response method according to any one of claims 7 to 10, wherein the third message comprises a first Simple Network Management Protocol SNMP request get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS; 35 the response message of the third message comprises a first SNMP response get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS; the fourth message comprises a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS; and the response message of the fourth message comprises a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS. 45

12. An OpenFlow controller OFC, applicable to a hybrid software-defined network SDN-Internet Protocol IP network, and comprising: 50

a message receiving module, configured to receive a first message forwarded by a first Open-Flow switch OFS, wherein a first port of the first OFS is connected to a second port of a first traditional switch TS, the first message is sent by the first TS to the first OFS, and the first message comprises identification information of the first TS and information about the second port; a message processing module, configured to determine information about a link from the first TS to the first OFS based on the first message; and

a message sending module, configured to send a second message to the first OFS, wherein the second message comprises a first instruction, and the first instruction is used to instruct the first OFS to forward the second message on the first port, so that the first TS obtains information about a link from the first OFS to the first TS, wherein

the message sending module is further configured to send a third message to the first OFS, wherein the third message is used to request management information base MIB information of the first TS, the third message carries a second instruction, and the second instruction is used to instruct the first OFS to forward the third message on the first port; the message receiving module is further configured to receive a response message, forwarded by the first OFS, of the third message, wherein the response message of the third message is sent by the first TS, and the response message of the third message carries the MIB information of the first TS; and

the message processing module is further configured to obtain, based on the MIB information of the first TS, the information about the link from the first OFS to the first TS and information about a link from a second TS connected to the first TS to the first TS.

13. The OFC according to claim 12, wherein the MIB message of the first TS comprises identification information of the second TS; the message sending module is further configured to send a fourth message to the first OFS, wherein the fourth message is used to request MIB information of the second TS, the fourth message carries a third instruction used to instruct the first OFS to forward the third message on the first port, the fourth message further comprises a source routing domain field, and the source routing domain field comprises the identification information of the second TS, and is used to instruct the first TS to forward the fourth message to the second TS; the message receiving module is further configured to receive a response message, forwarded by the

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first OFS, of the fourth message, wherein the response message of the fourth message is sent by the second TS, and the response message of the fourth message carries the MIB information of the second TS; and the message processing module is further configured to obtain information about a link from a third TS to the second TS based on the MIB information of the second TS, wherein the third TS is connected to the second TS.

14. The OFC according to claim 13, wherein the OFC comprises an IP MIB and an OpenFlow OpenFlow MIB; and the message processing module is further configured to: save the MIB information of the first TS and the MIB information of the second TS in the IP MIB of the OFC, and save, in the OpenFlow MIB, the information about the link from the first TS to the first OFS.

15. The OFC according to claim 13 or 14, wherein the third message comprises a first Simple Network Management Protocol SNMP request get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS; the response message of the third message comprises a first SNMP response get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS; the fourth message comprises a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS; and the response message of the fourth message comprises a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS.

16. The OFC according to claim 15, wherein the response message of the third message is a packet in message in which the first SNMP get-response message is encapsulated, the response message of the third message further comprises a reason field, and the reason field in the response message of the third message is used to indicate that the response message of the third message carries the MIB information of the first TS; and the response message of the fourth message is a packet in message in which the second SNMP get-response message is encapsulated, the response message of the fourth message further comprises a reason field, and the reason field in the response message of the fourth message is used to indicate that the response message of the fourth message carries the MIB information of the second TS.

17. The OFC according to any one of claims 12 to 16,

wherein a first Link Layer Discovery Protocol LLDP packet is encapsulated in the first message, and the first LLDP packet carries the identification information of the first TS and the information about the second port. 5

18. A traditional switch TS, serving as a first TS in a hybrid software-defined network SDN-Internet Protocol IP network, wherein the hybrid SDN-IP network further comprises an OpenFlow controller OFC, a first OpenFlow switch OFS, and a TS other than the first TS, and the TS comprises: 10

a message receiving module, configured to receive a third message on a second port of the first TS, wherein the third message is used by the OFC to request management information base MIB information of the first TS; and 15

a message sending module, configured to send a response message of the third message on the second port, wherein the response message of the third message carries the MIB information of the first TS. 20

19. The TS according to claim 18, wherein the second port of the first TS is connected to a first port of the first OFS, and the OFC instructs the first OFS to forward the third message on the first port. 25

20. The TS according to claim 18, wherein the second port of the first TS is connected to a target TS other than the first TS in the hybrid SDN-IP network, and the OFC instructs the target TS to forward the third message to the first TS. 30

21. The TS according to any one of claims 18 to 20, wherein 35

the message receiving module is further configured to receive a fourth message on the second port, wherein the fourth message is used to request MIB information of a second TS, the fourth message comprises a source routing domain field, the source routing domain field comprises identification information of the second TS, and the second TS is connected to the first TS; 40

the message sending module is further configured to forward the fourth message to the second TS according to an instruction of the source routing domain field; 45

the message receiving module is further configured to receive a response message, returned by the second TS, of the fourth message, wherein the response message of the fourth message carries the MIB information of the second TS; and 50

the message sending module is further configured to send the response message of the fourth message on the second port. 55

22. The TS according to any one of claims 18 to 21, wherein the third message comprises a first Simple Network Management Protocol SNMP request get-request message, and the first SNMP get-request message is used to request the MIB information of the first TS; the response message of the third message comprises a first SNMP response get-response message, and the first SNMP get-response message is used to carry the MIB information of the first TS; the fourth message comprises a second SNMP get-request message, and the second SNMP get-request message is used to request the MIB information of the second TS; and the response message of the fourth message comprises a second SNMP get-response message, and the second SNMP get-response message is used to carry the MIB information of the second TS. 60

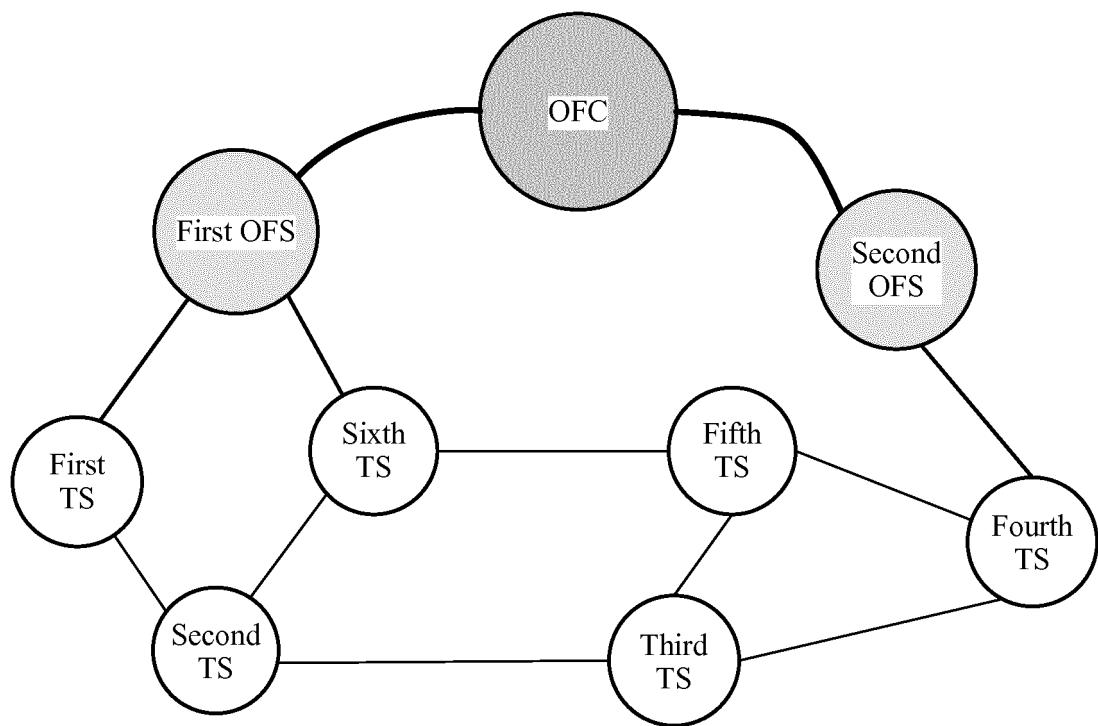


FIG. 1

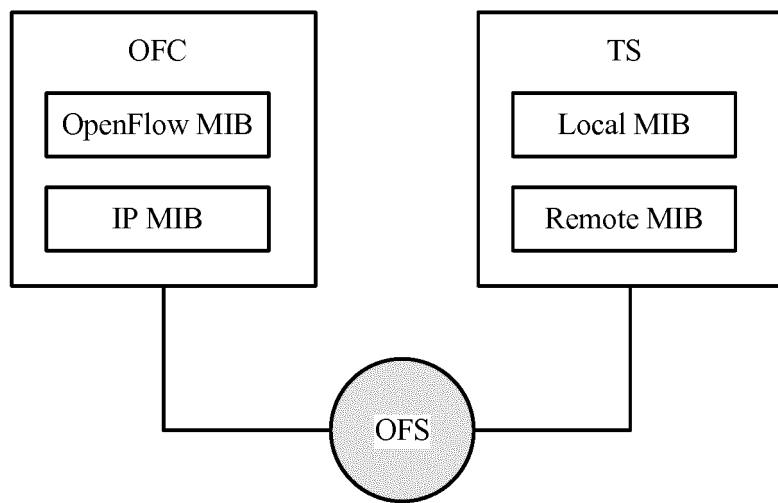


FIG. 2

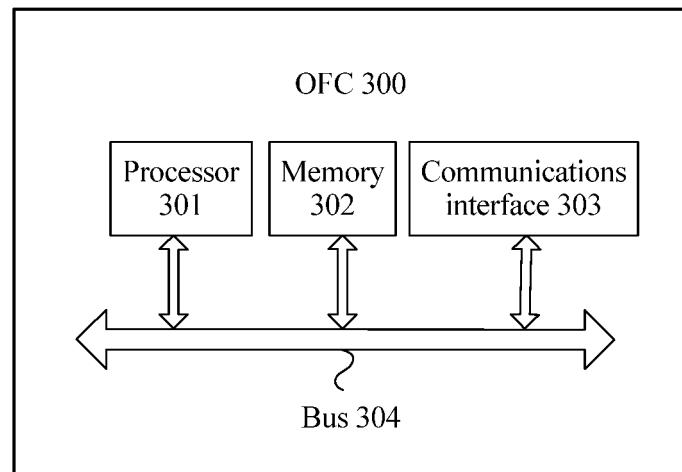


FIG. 3 (a)

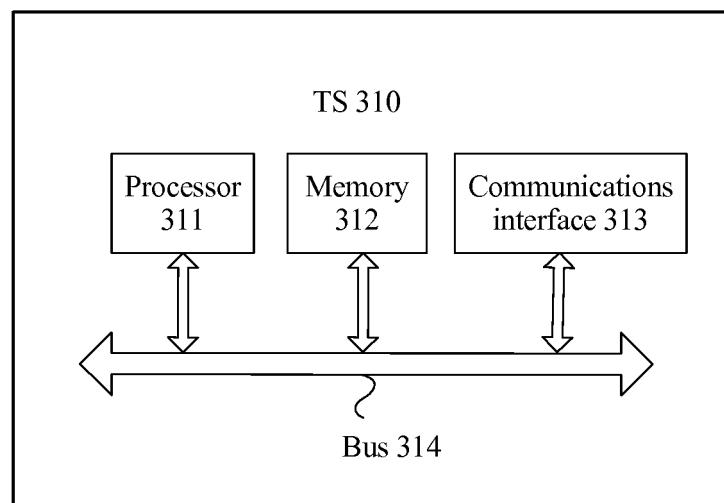


FIG. 3 (b)

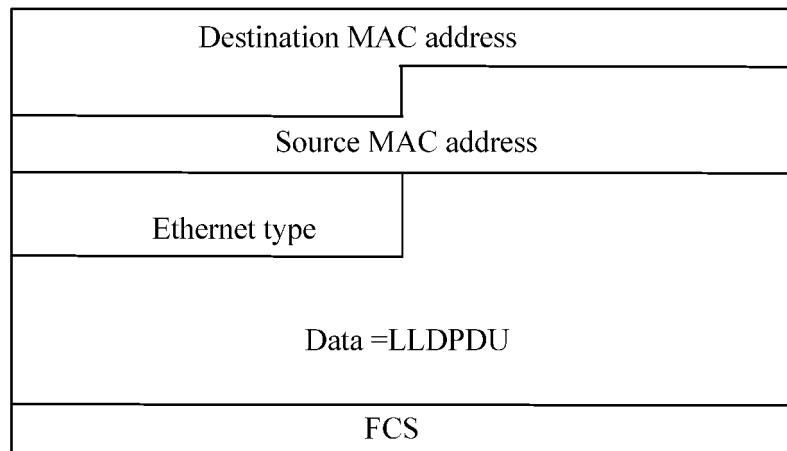


FIG. 4 (a)

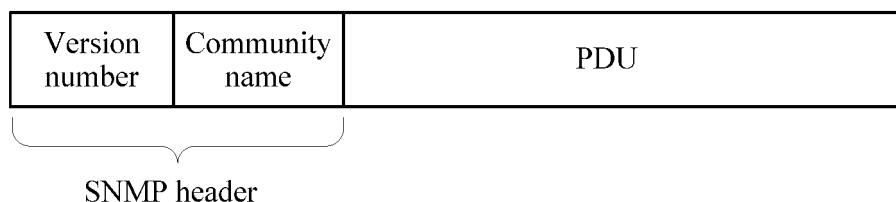


FIG. 4 (b)

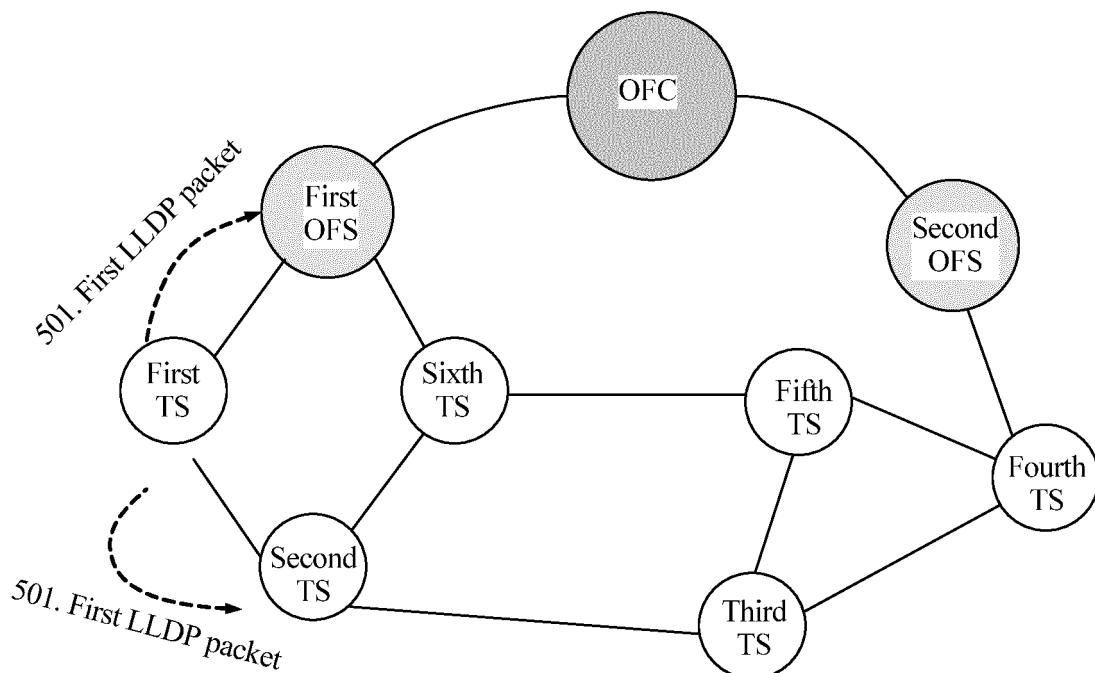


FIG. 5 (a)

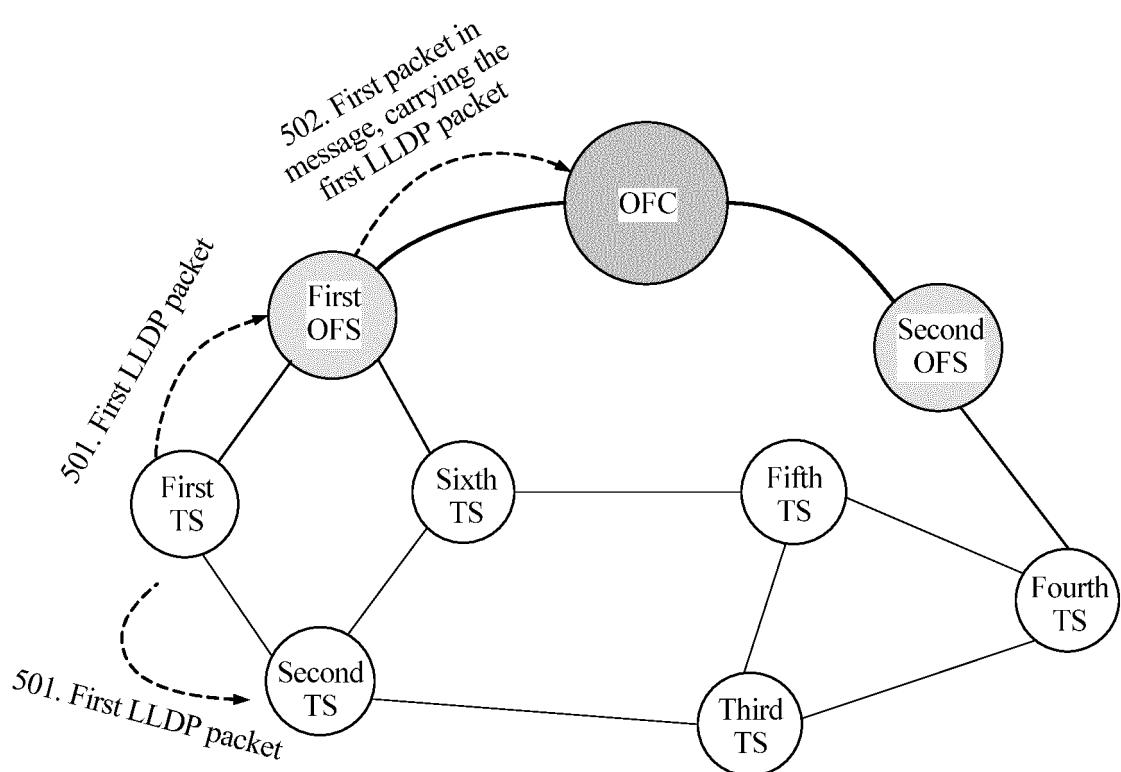


FIG. 5 (b)

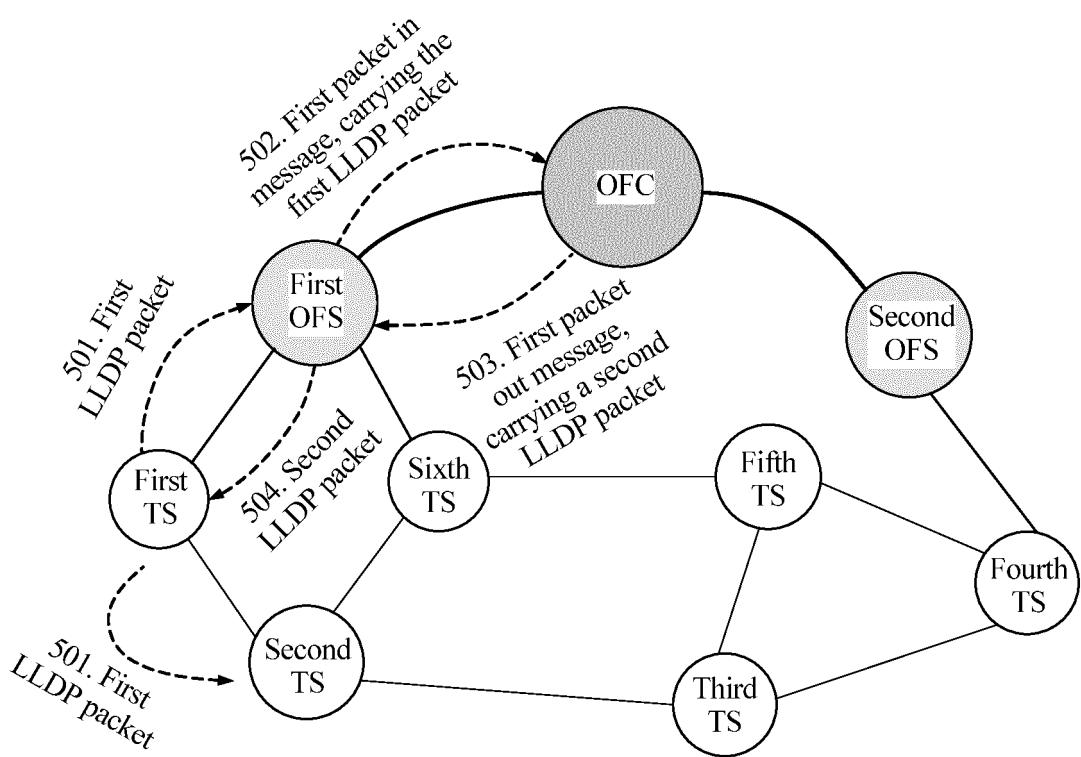


FIG. 5 (c)

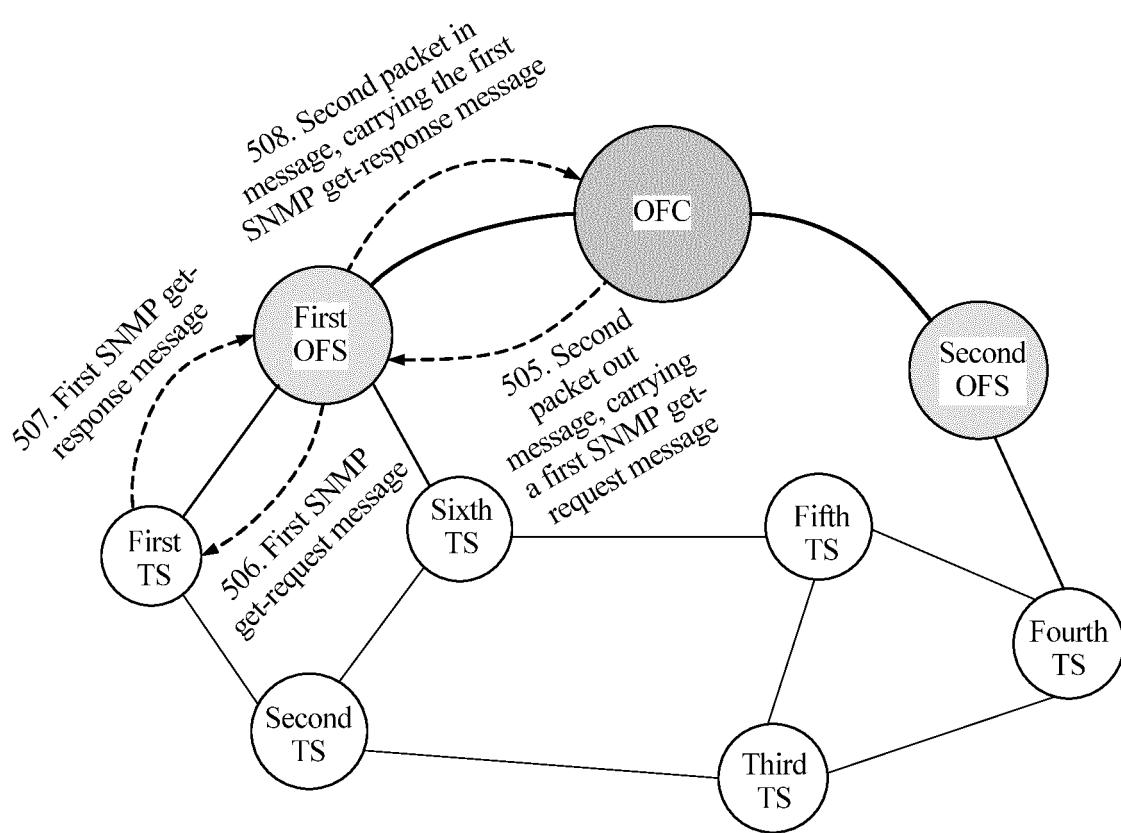


FIG. 5 (d)

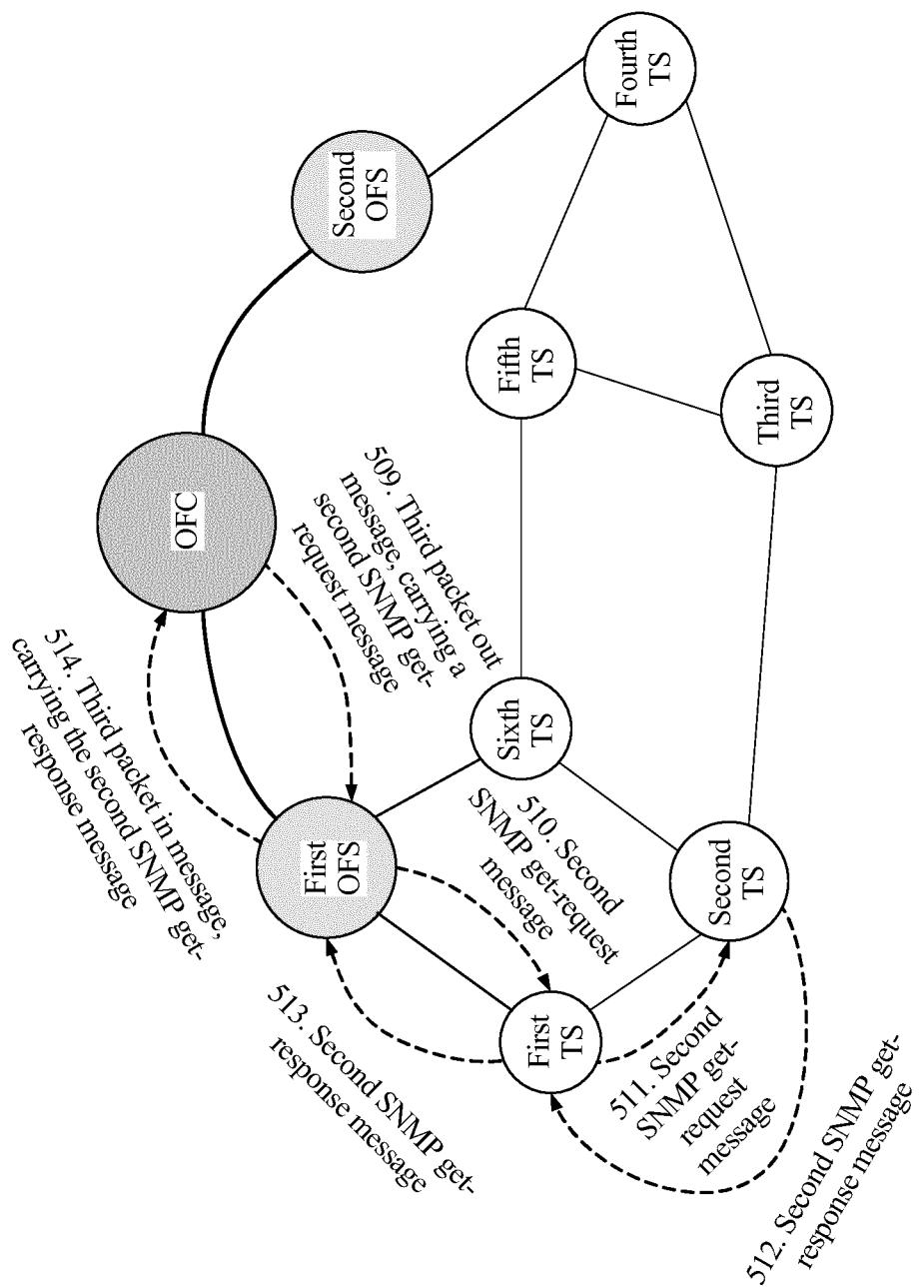


FIG. 5 (e)

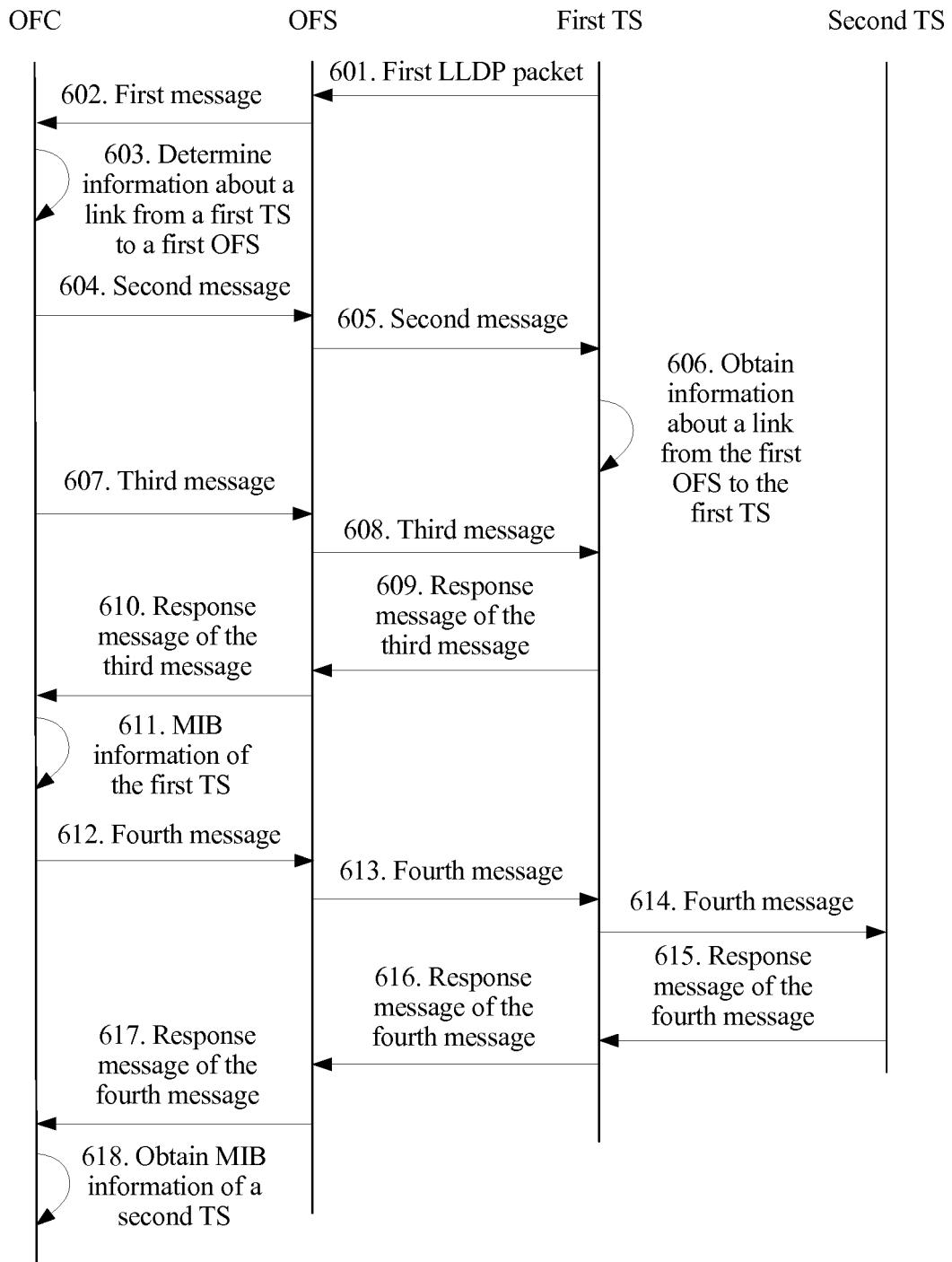


FIG. 6

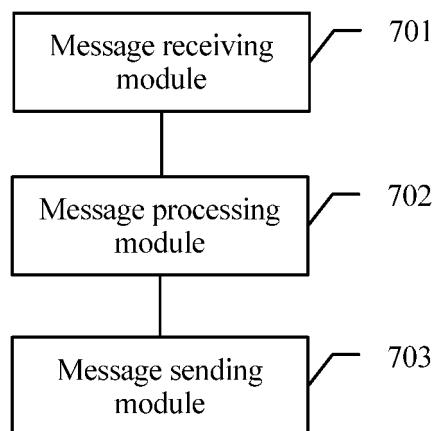


FIG. 7

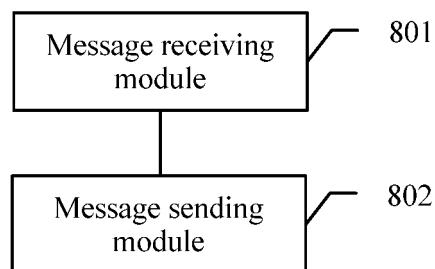


FIG. 8

| <b>INTERNATIONAL SEARCH REPORT</b>  | International application No.<br><b>PCT/CN2017/077120</b>   |                       |  |                       |   |   |      |   |  |      |   |  |      |
|---|---|-----------------------|--|-----------------------|---|---|------|---|--|------|---|--|------|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b> <p style="text-align: center;">H04L 12/751 (2013.01) i<br/>According to International Patent Classification (IPC) or to both national classification and IPC</p>   |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| <b>B. FIELDS SEARCHED</b> <p>Minimum documentation searched (classification system followed by classification symbols)</p> <p style="text-align: center;">H04L</p>  |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched   |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>CNPAT; WPI; EPODOC; CNKI; IEEE: management information base, response, software defined network, MIB, software, traditional, IP, defined, OFC, network, internet protocol, hybrid software defined network, switch, OpenFlow controller, OpenFlow, OpenFlow switch, controller, OFS, SDN, traditional switch, TS  |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 80%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 10%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>CN 104579968 A (HUAWEI TECHNOLOGIES CO., LTD.), 29 April 2015 (29.04.2015), description, paragraphs [0004]-[0005]</td> <td style="text-align: center;">1-22</td> </tr> <tr> <td>A</td> <td>CN 104734988 A (HANGZHOU HUAWEI DIGITAL TECHNOLOGY CO., LTD.), 24 June 2015 (24.06.2015), the whole document</td> <td style="text-align: center;">1-22</td> </tr> <tr> <td>A</td> <td>US 2016080254 A1 (HUAWEI TECHNOLOGIES CO., LTD.), 17 March 2016 (17.03.2016), the whole document</td> <td style="text-align: center;">1-22</td> </tr> </tbody> </table> |   | Category*             | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. | A | CN 104579968 A (HUAWEI TECHNOLOGIES CO., LTD.), 29 April 2015 (29.04.2015), description, paragraphs [0004]-[0005] | 1-22 | A | CN 104734988 A (HANGZHOU HUAWEI DIGITAL TECHNOLOGY CO., LTD.), 24 June 2015 (24.06.2015), the whole document | 1-22 | A | US 2016080254 A1 (HUAWEI TECHNOLOGIES CO., LTD.), 17 March 2016 (17.03.2016), the whole document | 1-22 |
| Category*   | Citation of document, with indication, where appropriate, of the relevant passages                                | Relevant to claim No. |  |                       |   |   |      |   |  |      |   |  |      |
| A   | CN 104579968 A (HUAWEI TECHNOLOGIES CO., LTD.), 29 April 2015 (29.04.2015), description, paragraphs [0004]-[0005] | 1-22                  |  |                       |   |   |      |   |  |      |   |  |      |
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| <p style="text-align: center;"><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.</p>   |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
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| Date of the actual completion of the international search<br>02 May 2017 (02.05.2017)   |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| Date of mailing of the international search report<br><b>08 June 2017 (08.06.2017)</b>  |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| Name and mailing address of the ISA/CN:<br>State Intellectual Property Office of the P. R. China<br>No. 6, Xitucheng Road, Jimenqiao<br>Haidian District, Beijing 100088, China<br>Facsimile No.: (86-10) 62019451  |   |                       |  |                       |   |   |      |   |  |      |   |  |      |
| Authorized officer<br><b>GONG, Lei</b><br>Telephone No.: (86-10) <b>62413375</b>  |   |                       |  |                       |   |   |      |   |  |      |   |  |      |

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**INTERNATIONAL SEARCH REPORT**  
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